Ontario

Structural Financial Analysis Manual

Ministry
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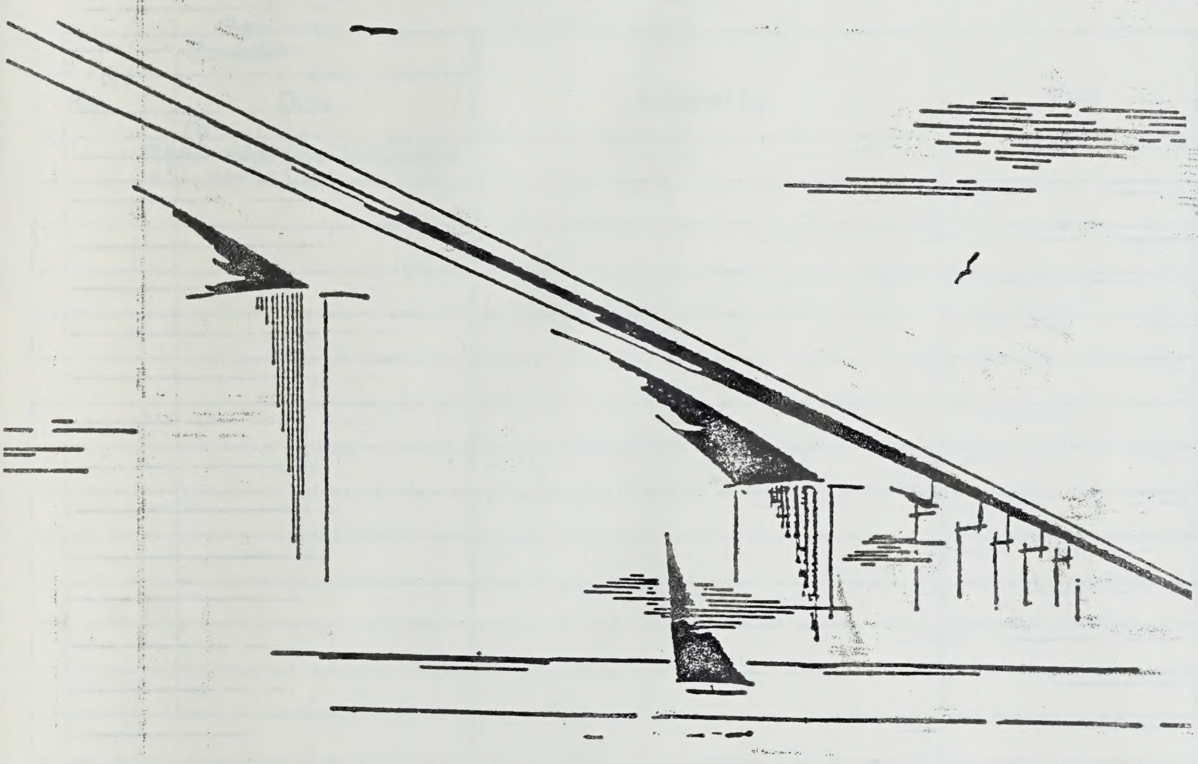
Manual SO 11



Structural

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CONTINUING RECORD OF REVISIONS MADE
to the Manual

STRUCTURAL FINANCIAL ANALYSIS

This sheet should be retained permanently in this page sequence in the Manual.
All revised material should be inserted as soon as received and the relevant entries made by hand in the spaces provided to show who incorporated the Revision and the date this was done.
If this practice is followed faithfully it will be a simple matter to tell whether or not this copy of the Manual is up to date since all future Revisions will be numbered and dated.

Revision		Entered by	Date
No.	Date		
	This reprint includes all revisions		

STRUCTURAL FINANCIAL

ANALYSIS MANUAL

S F A M

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S F A M

CONTENTS

INTRODUCTION:

The capital cost for a structure is seldom a one-time cost. Throughout the life of the structure it requires periodic maintenance, rehabilitation and replacement of various components, or the replacement of the structure.

The goals of the financial analysis are to make rational choices regarding competing options both at the project and at the network levels. The main objectives are to arrive at the most economical solutions for rehabilitation and replacement of structures and to ensure that funds are expended in an effective manner.

At the project level costs of alternative levels of improvements to a structure are compared in determining the most economical option for the structure. At the network level, resources are allocated between structures which may have different degrees of defects, deteriorations and deficiencies.

The present value analysis or the incremental benefit/cost ratio analysis may be used for decision making among competing alternatives at the project level. The incremental benefit/cost ratio analysis is used for decision making among different structures at the net-work level.

Part 1 of this manual outlines the technique used in carrying out the present value analysis at the project level. Part 2 deals with the use of incremental benefit-cost ratio analysis at the project level, and Part 3 outlines the incremental benefit-cost ratio analysis at the network level.

DEFINITIONS

Constant Dollar	-	The value of goods and services in dollars which have the same general value/purchasing power over time.
Discount Rate	-	The rate used to discount a future cost to obtain the present value. (Rate recommended by the Treasury Board of Canada or the ministry responsible for public projects.)
Life Cycle	-	Time between two successive replacements or rehabilitation operations.
Ministry	-	Ministry of Transportation of Ontario.
Nominal Dollar	-	The value of goods and services in terms of "cash" price or "cost" at the time the survey is taken.
Present Value	-	The value in today's dollar to obtain goods and services at any future date.
Rehabilitation	-	Any modification, alteration or improvement to a structure or its components which is designed to correct defects, deterioration and deficiencies for a particular life and live load level.
Residual Life	-	The useful life of the structure at the end of the time frame considered.
Residual Value	-	The value in dollars of an alternate at the end of the time frame considered in the analysis.
Sensitivity Analysis	-	A technique where different values for uncertain variables are used to construct alternative scenarios of outcomes.
Structure	-	Bridge, culvert, tunnel, retaining wall or sign support structure.

NOTATIONS

C -	Cost
C^e -	Expected cost
C_n -	Estimated cost
f -	General inflations rate
f^1 -	Inflation in the Construction Industry - Comparable to the tender price index
N -	Life cycle in years; the period in years considered for life cycle analysis.
n -	Number of years
P -	Principal
p_n -	Probability of occurrence
PV -	Present value
r -	Discount rate
V_c -	Estimated variation of cost
Cu -	Uniform cost
g -	Gradient

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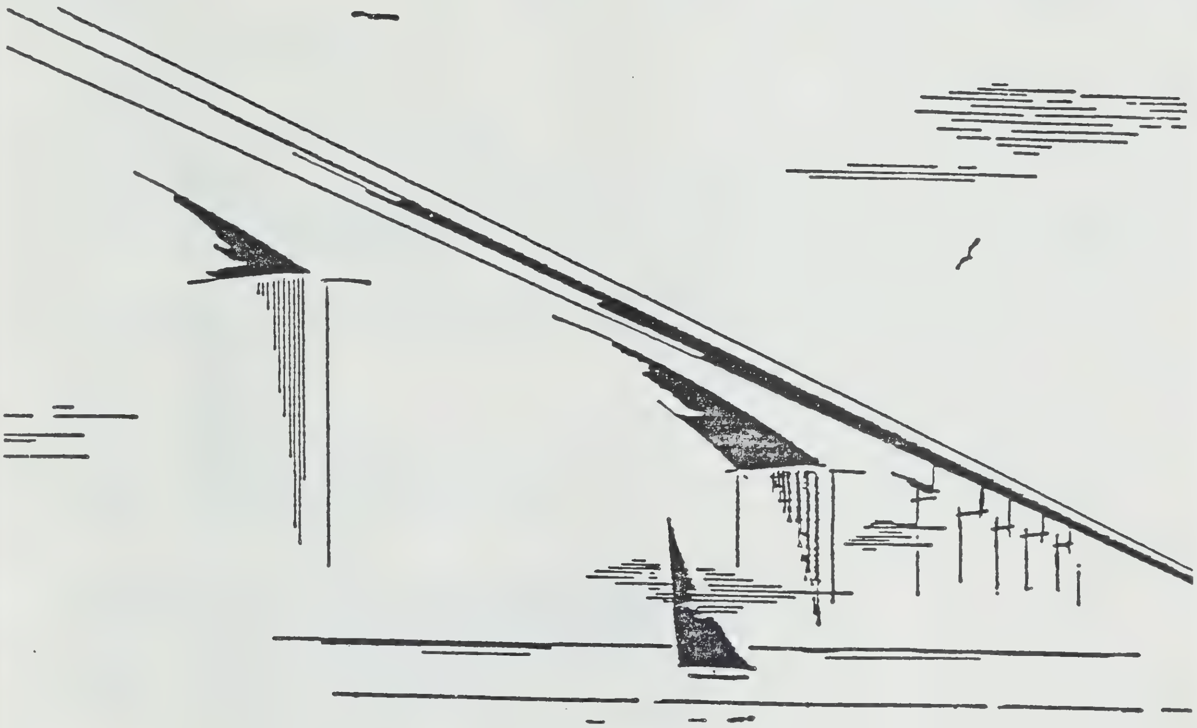


Structural Financial Analysis Manual

PART 1 -- PRESENT VALUE ANALYSIS

-- PROJECT LEVEL --

Part 1 - Present Value Analysis

Part 1 - Present Value Analysis

1.1 Scope

The present value analysis technique is used to choose between competing alternatives of rehabilitation and replacement options for structures at the project level. Software based on Lotus 1-2-3, Version 2.01 is used to carry out the analysis and the procedures are illustrated with examples.

1.2 Present Value Analysis

The present value analysis technique involves the calculation of the cost of alternative schemes in present day dollars, i.e. the dollars that are required in today's value to obtain goods and services at any future date. This is based on the simple investment principle:

A capital or principal P invested for n years at an interest rate r, compounds to a sum C such that,

$$C = P(1 + r)^n$$

or restated, the present value P, of a capital C spent in year n at a discount rate r is given by,

$$P = \frac{C}{(1 + r)^n}$$

This is the basis for the present value analysis. For further details of the theory of present value analysis see Appendix A.1.1

In general, when comparing alternatives, the alternative with the least present cost is the preferred alternative. This allows for the comparison of alternative schemes on an equitable basis.

1.3 Inflation

Variations in costs may occur due to general inflation or deflation. All cost estimates of engineering projects should be carried out in constant dollars. Treasury Board's publication on Guide to Benefit-Cost Analysis[1] recommends that these cost estimates should not be increased for inflation.

For details of the effect of inflation on the analysis see Appendix A.1.2.

1.4 Project Level Financial Analysis

1.4.1 General

At the project level the financial analysis may be undertaken for the whole structure or a major component of it.

1.4.2 Levels of Analysis

The present value analysis may be carried out at four levels of sophistication depending on the availability of reliable information pertaining to various costs. The reliability increases from level 1 to level 4.

a) Level 1 Analysis - Capital Costs

Uses only the capital costs involved during the assumed life cycle. The residual value of the structure and the maintenance costs are neglected.

b) Level 2 Analysis - Capital Costs and Residual Values

Uses the capital costs and residual values but excludes maintenance costs.

c) Level 3 Analysis - Capital Costs, Residual Values and Maintenance Costs

Uses all associated costs including capital costs, residual values and maintenance costs.

d) Level 4 Analysis - Probability Analysis

This is same as level 3 but includes a probability analysis allowing for uncertainty with respect to costs.

1.4.3 Sensitivity Analysis

When the magnitude of the discount rate to be used is in question, a sensitivity analysis may be performed by varying the discount rate. This may be carried out at any of the four levels of analysis. The sensitivity analysis would assist the decision-maker in arriving at a more cost effective solution.

1.5 Parameters Required for the Financial Analysis

1.5.1 General

The following parameters are required to perform the financial analysis. Table 1.5.1 indicates which of these parameters are needed for the various levels of financial analysis.

a) Parameters related to the proposed rehabilitation or replacement of each alternative.

- Capital costs
- Life cycle
- Residual life
- Future maintenance costs

b) Parameters related to the existing condition of the structure.

- Estimated residual life without remedial work.

c) Discount Rate

- Rate recommended by the Treasury Board of Canada
- Variations in discount rate

Table 1.5.1 - Levels of Financial Analysis

Parameters	Level 1 Analysis	Level 2 Analysis	Level 3 Analysis	Level 4 Analysis
Capital Costs	Yes	Yes	Yes	Yes
Life Cycle	Yes	Yes	Yes	Yes
Discount rate	Yes	Yes	Yes	Yes
Residual Life		Yes	Yes	Yes
Future maintenance costs			Yes	Yes
Probabilities in cost variations				Yes

1.5.2 Capital Cost

These costs include the following:

a) Replacement cost

b) Rehabilitation cost

The Project Engineer should estimate the following costs for each alternative in constant dollar terms.

. Engineering design cost
. Construction cost, including traffic and enviornmental protection costs.
. Miscellaneous costs such as:
  . Demolition
  . Right-of-Way
  . Approaches
  . Utilities
  . Stream diversion
  . Detours,
  . Others

1.5.3 Life Cycle

The Project Engineer should estimate the time period over which the financial analysis is to be carried out, usually 50 years. The life cycle of each alternative should be estimated. Usually, it is the time between two successive replacements or rehabilitations.

For example, the life cycle of a new deck with epoxy coated reinforcement is about 50 years, but the life cycle of the asphaltic pavement is about 15 years. Assumed life cycles for various types of rehabilitations are given in Appendix A.1.3.

1.5.4 Residual Life

The various alternatives considered may have useful lives at the end of the time-period. This is termed as the residual life. Assessment of residual life is a difficult task. There are no specific methods in assessing this. A thorough knowledge of the performance of past rehabilitations and experienced engineering judgement are probably the best way of assessing the useful residual life. From the residual life, the residual value of the structure is calculated. See Appendix A.1.4. for details.

1.5.5 Maintenance Costs

Costs associated with maintenance include minor repairs, maintenance, touch-up painting, etc., carried out on a regular basis to minimize the incidence of costly and dangerous situations that may arise from deterioration of the structure.

The impact of maintenance costs is generally not very significant on the majority of projects, but may be useful to consider when the present value of two alternatives are close to each other. However, if these costs are not available the analysis could be performed without them. Costs for routine maintenance may be available from the District Maintenance office or Maintenance Branch.

1.5.6 Probabilities of Occurrences

In an environment of uncertainties determining accurate cost estimates is difficult. The project engineer should assign the estimated variations of costs, V_c, and the probability of their occurrence, p_n taking into account variables such as local environmental conditions, construction climate etc.

If $C_1, C_2, \ldots\ldots C_n$ are n estimated costs with probabilities of occurrence, $p_1, p_2, \ldots\ldots\ldots\ldots p_n$ for an option, then the expected cost C^e for that option is given by:

$$C^e = p_1C_1 + p_2C_2 + \ldots\ldots\ldots + p_nC_n$$

Table 1.5.6 shows the cost variations and the probabilities of occurrence for a rehabilitation project with two options. Each option is assessed to have the following four possible variations in cost.

- Same as the estimated cost;
- 10% less than the estimated cost;
- 10% more than the estimated cost;
- 20% more than the estimated cost

Probabilities assigned to each of these cost variations are assessed at 0.6, 0.15, 0.15, 0.1 respectively, for option 1, i.e.

- 0.6 is the probability that the estimate is same as calculated;
- 0.15 is the probability that the cost is 10% less, or 10% more than the estimate;
- 0.10 is the probability that the cost is 20% more than the estimate.

Similarly, probabilities of 0.7, 0.10, 0.15 and 0.05 are assigned to the cost variations for option 2.

Table 1.5.6 - Cost Uncertainties

Estimated Variation of Cost (V_c)	Estimated Cost (C_n)	Probability of Occurrence (p_n) Option (1)	Option (2)
V_1 = As calculated	$C_1 = C_n$	$p_1 = 0.60$	$p_1 = 0.70$
$V_2 = -10\%$	$C_2 = 0.9C_n$	$p_2 = 0.15$	$p_2 = 0.10$
$V_3 = +10\%$	$C_3 = 1.1C_n$	$p_3 = 0.15$	$p_3 = 0.15$
$V_4 = +20\%$	$C_4 = 1.2C_n$	$p_4 = 0.10$	$p_4 = 0.05$
		$\sum p_n = 1.00$	$\sum p_n = 1.00$

Expected cost, C^e (option 1) $= 0.6C_1 + 0.15C_2 + 0.15C_3 + 0.1C_4$

Expected cost, C^e (option 2) $= 0.7C_1 + 0.1C_2 + 0.15C_3 + 0.05C_4$

1.5.7 Discount Rate

Benefits and costs of government expenditure may be realized over different time periods. To allow projects to be compared on an equitable basis the costs and benefits should be multiplied by a discount factor.

$$\text{Discount factor} = \frac{1}{(1+r)^n}$$

Where r is the discount rate and n is the number of the years. The appropriate discount rate for government projects will depend on several factors[2], such as magnitude of investment return, tax rates, capital market conditions, preferences for current and future consumption, methods used to finance projects etc.

Treasury Board's publication on 'Guide to Benefit-Cost Analysis'[1], recommends that analysts use a discount rate of 10% and perform a sensitivity analysis using discount rates of 5% and 15%. NCHRP 293[3] recommends a discount rate of 6% for Bridges in USA.

A discount rate of 6% is recommended in this manual. Sensitivity analysis should be carried out by varing the discount rate.

1.6 Present Value Analysis Using PRVAL Program

PRVAL is a template overlay developed to perform financial analysis for bridge rehabilitation projects using Lotus 1-2-3, Version 2.01, on a worksheet format. There are four different options available to carry out the financial analysis as given in Section 1.4.2. Sensitivity analysis can be carried out for each level by varying the discount rate.

This program carries out the analysis as the input is entered.

The four options available are:

PRVAL01.WK1 - Level 1 Analysis - Capital Costs.

PRVAL02.WK1 - Level 2 Analysis - Capital Costs and Residual Values.

PRVAL03.WK1 - Level 3 Analysis - Capital Costs, Residual Values and Maintenance Costs

PRVAL04.WK1 - Level 4 Analysis - Probability Analysis

1.6.1 Running PRVAL from Floppy Disk Drives

The PRVAL01.WK1, PRVAL02.WK1, PRVAL03.WK1 and PRVAL04.WK1 files are in a directory called PRVAL on the disk 1 supplied with this manual.

Load Lotus 1-2-3, Version 2.01 and retrieve PRVAL directory to choose the four files in that directory.

1.6.2 Running PRVAL from Hard Disk Drive

Create a subdirectory called PRVAL and copy the four files PRVAL01.WK1, PRVAL02.WK1, PRVAL03.WK1 and PRVAL04.WK1 into PRVAL subdirectory. Load Lotus 1-2-3, Version 2.01, and retrieve the subdirectory PRVAL to choose the four files in that subdirectory.

1.6.3 INPUT SCREENS FOR PRVAL PROGRAM

INSTRUCTIONS TO USER:

During the analysis if you wish to access Instructions to user screen or input tables to make changes, do the following :

INSTRUCTIONS TO USER:	alt.h
INPUT 1	alt.i
INPUT 2	alt.j
INPUT 3	alt.k
INPUT 4	alt.l
INPUT 5	alt.m
Print	alt.p

- alt.a builds up the required Input table 3 from data in INPUT 1
- Do not press alt.a to do revisions, unless the number of options are different.

INPUT -1- COST ESTIMATE FOR EACH TREATMENT

Name of Structure :	(max. 14 characters)
Site Number :	(start with ')
Number of Options Considered :	(max 4)
Discount Rate :	(0.06 recommended)
Number of Rows to be ent^red :	(max 50)
Time period :	(normally 50 years)

COMMENTS :

- This screen is common to all four levels.
- The Discount Rate must be expressed in decimal form to two places.
- Number of rows to be entered. These are the rows to be entered in INPUT 3. For levels 1 and 2 fifteen rows are recommended. For levels 3 and 4 the recommended maximum is fifty. However the program can handle more than fifty.

INPUT -2- COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Design				
Construction				
Demolition				
Right-of-Way				
Approaches				
Utilities				
Creek Diversion				
Detour				
Other				
Total	$0	$0	$0	$0

COMMENTS :

- This table is common to all four levels.
- Under each Treatment describe the type of rehabilitation or replacement.
  (2 rows are available for this.)
- Enter cost estimates for each treatment under the headings shown.
  These headings were chosen to ensure all costs are accounted for.
- Totals are calculated by the program automatically.

INPUT 3 - LIFE CYCLE COST DATA

Year	Option 1	Option 2	Option 3	Option 4

COMMENTS :

- This table is common to all four levels.
- The costs are obtained from Input 2.
- Enter the year and the costs which occur in that year for each option.
- The table size will vary according to the number of rows and the number of options entered in Input 1.

INPUT -4- SECOND CYCLE REPLACEMENT
TO DETERMINE RESIDUAL VALUE

Options	Replacement Year	Cost
1		
2		
3		
4		

COMMENTS :

- This table is required for levels 2,3 and 4
- Enter Second Cycle Replacement costs in constant dollar terms.
  i.e. the second cycle replacement COST is the same for each option, but the second cycle replacement YEAR is different.

INPUT -5- TABLE FOR COST UNCERTAINTIES

Estimated Variation of Cost Vc	Estimated Cost (Cn)	Probability of Occurrence (pn)			
		Option 1	Option 2	Option 3	Option 4
V1 = As Calculated	Cn	P1 =	P1 =	P1 =	P1 =
V2 = %	1.00 Cn	P2 =	P2 =	P2 =	P2 =
V3 = %	1.00 Cn	P3 =	P3 =	P3 =	P3 =
V4 = %	1.00 Cn	P4 =	P4 =	P4 =	P4 =
		0.00	0.00	0.00	0.00

COMMENTS :

- This table is required only for level 4 analysis.
- Enter % of variations.
- Enter probabilities of occurrence.
- A sound judgement is required in assigning probabilities to the different cost variations.

1.6.4 PRINTING OUTPUT from PRVAL Program.

- After all the input has been entered and the program has finished the calculations, save the file under a unique name.
- To print the output files type alt.p

1.7 Examples of Financial Analysis

The example is the selection of the most economical option for a deck rehabilitation project. The project engineer has come up with the following data and options as part of his engineering assessment.

a) The time period to be considered is 50 years.

b) The life cycle for each treatment is as follows:

1.	Deck replacement	50 years
2.	Rehabilitation - Overlay, Waterproof and Pave	30 years
3.	Milling and replacing top asphalt surface	15 years
4.	Replace waterproofing and asphalt	30 years
5.	Residual life without rehabilitation	5 years

c) The cost of each rehabilitation type is given in Table 1.7:

	Table 1.7 Costs			
	Rehabilitation			
	Treatment 1	Treatment 2	Treatment 3	Treatment 4
	Deck Replacement	Overlay, Waterproof and pave	Milling & Replacing top asphalt surface	Replace Waterproofing and asphalt
Design cost	50,000	30,000	5,000	5,000
Construction cost	700,000	450,000	80,000	190,000
Demolition	-	-	-	-
Right of way	-	-	-	-
Approaches	50,000	20,000	5,000	5,000
Utilities	-	-	-	-
Creek diversion	-	-	-	-
Detours	200,000	100,000	10,000	50,000
Others	-	-	-	-
Total	1,000,000	600,000	100,000	250,000

d) The three options considered are:

Option (1) Immediate rehabilitation: overlay, waterproof and pave. This would extend the useful life of the deck by 30 years, after which the deck will be replaced.

. In year 15 mill and replace the top asphalt surface
. In year 30 replace deck
. In year 45 mill and replace the top asphalt surface
. No further capital cost till year 50 but the
. deck will have to be replaced in year 80

Option (2) Do nothing now and replace the deck, waterproof and pave in 5 years, at the end of the useful life of the deck.

. In year 20 mill and replace the top asphalt surface
. In year 35 replace waterproofing and asphalt
. In year 50 mill and replace the top asphalt
. Since the life cycle of replacement is 50 years, the bridge will need to be replaced in year 55.

Option (3) Immediate replacement of the deck, waterproof and pave

. In year 15 mill and replace the top asphalt surface
. In year 30 replace waterproofing and asphalt
. In year 45 mill and replace top asphalt surface
. In year 50, time for another replacement. A decision has to be made at that time.

Financial analysis is performed at the four different levels of sophistication, for the above example as shown in Sections 1.7.1 to 1.7.4.

1.7.1 FINANCIAL ANALYSIS (LEVEL 1)

INPUT -1- GENERAL

Name of Structure :	B.M BRIDGE 1	(max. 14 characters)
Site Number :	23-0001	(start with ')
Number of Options Considered :	3	(max 4)
Discount Rate :	0.06	(0.06 recommended)
Number of Rows to be entered :	8	(max 15)
Life Cycle for Replacement :	50	

INPUT - 2 - COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1 Deck Replace-ment	Treatment 2 O/lay, Water proof & Pave	Treatment 3 Mill & Repl. top course	Treatment 4 Repl. Water proof & Asph.
Design	50000	30000	5000	5000
Construction	700000	450000	80000	190000
Demolition				
Right-of-Way				
Approaches	50000	20000	5000	5000
Utilities				
Creek Diversion				
Detour	200000	100000	10000	50000
Other				
Total	$1,000,000	$600,000	$100,000	$250,000

INPUT - 3 - COST DATA FOR EACH OPTION

Year	Option 1	Option 2	Option 3
0	600000		1000000
5		1000000	
15	100000		100000
20		100000	
30	1000000		250000
35		250000	
45	250000		100000
50		100000	

OUTPUT - LEVEL 1 ANALYSIS

Year	OPTION 1		OPTION 2		OPTION 3	
	Cost	Pres.Value	Cost	Pres.Value	Cost	Pres.Value
0	600,000	600,000	0	0	1,000,000	1,000,000
5	0	0	1,000,000	747,258	0	0
15	100,000	41,727	0	0	100,000	41,727
20	0	0	100,000	31,180	0	0
30	1,000,000	174,110	0	0	250,000	43,528
35	0	0	250,000	32,526	0	0
45	250,000	18,163	0	0	100,000	7,265
50	0	0	100,000	5,429	0	0
Total Present Value:		$833,999		$816,394		$1,092,519

1.7.2 FINANCIAL ANALYSIS (LEVEL 2)

INPUT -1- GENERAL

Name of Structure	:B.M BRIDGE 2	(max. 14 characters)
Site Number	:23-0002	(start with ')
Number of Options	: 3	(max 4)
Discount Rate	: 0.06	(0.06 recommended)
Number of Rows to be entered	: 8	(max 50)
Life Cycle for Replacement	: 50	

INPUT -2- COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1 Deck Replacement	Treatment 2 O/lay, Water proof & Pave	Treatment 3 Mill & Repl. top course	Treatment 4 Repl. Water proof & Asph.
Design	50,000	30,000	5,000	5,000
Construction	700,000	450,000	80,000	190,000
Demolition				
Right-of-Way				
Approaches	50,000	20,000	5,000	5,000
Utilities				
Creek Diversion				
Detour	200,000	100,000	10,000	50,000
Other				
Total	$1,000,000	$600,000	$100,000	$250,000

INPUT -3- COST DATA FOR EACH OPTION

Year	Option 1	Option 2	Option 3
0	600,000		1,000,000
5		1,000,000	
15	100,000		100,000
20		100,000	
30	1,000,000		250,000
35		250,000	
45	100,000		100,000
50		100,000	

INPUT -4- SECOND CYCLE REPLACEMENT
TO DETERMINE RESIDUAL VALUE

Option	Replacement Year	Cost
1	80	1,000,000
2	55	1,000,000
3	50	1,000,000

OUTPUT - LEVEL 2 ANALYSIS

Year	OPTION 1		OPTION 2		OPTION 3	
	Cost	Pres.Value	Cost	Pres.Value	Cost	Pres.Value
0	600,000	600,000	0	0	1,000,000	1,000,000
5	0	0	1,000,000	747,258	0	0
15	100,000	41,727	0	0	100,000	41,727
20	0	0	100,000	31,180	0	0
30	1,000,000	174,110	0	0	250,000	43,528
35	0	0	250,000	32,526	0	0
45	100,000	7,265	0	0	100,000	7,265
50	0	0	100,000	5,429	0	0
Total Present Value:		$823,102		$816,394		$1,092,519
Residual Value :		($44,836)		($13,721)		$0
		=============		=============		=============
Net Present Value :		$778,265		$802,673		$1,092,519

1.7.3 FINANCIAL ANALYSIS (LEVEL 3)

INPUT -1- GENERAL

Name of Structure :	B.M BRIDGE 3	(max. 14 characters)
Site Number :	23-0003	(start with ')
Number of Options Considered :	3	(max 4)
Discount Rate :	0.06	(0.06 recommended)
Number of Rows to be entered :	50	(max 50)
Life Cycle for Replacement :	50	

INPUT -2- COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1 Deck Replacement	Treatment 2 O/lay, Water proof & Pave	Treatment 3 Mill & Repl. top course	Treatment 4 Repl. Water proof & Asph.
Design	50,000	30,000	5,000	5,000
Construction	700,000	450,000	80,000	190,000
Demolition				
Right-of-Way				
Approaches	50,000	20,000	5,000	5,000
Utilities				
Creek Diversion				
Detour	200,000	100,000	10,000	50,000
Other				
Total	$1,000,000	$600,000	$100,000	$250,000

INPUT -3- COST DATA FOR EACH OPTION

Year	Option 1	Option 2	Option 3
0	600,000	10,000	1,000,000
1	3,000	10,000	2,000
2	3,000	10,000	2,000
3	3,000	10,000	2,000
4	3,000	10,000	2,000
5	3,000	1,000,000	2,000
6	8,000	2,000	7,000
7	8,000	2,000	7,000
8	8,000	2,000	7,000
9	8,000	2,000	7,000
10	8,000	2,000	7,000
11	10,000	7,000	10,000
12	10,000	7,000	10,000
13	10,000	7,000	10,000
14	10,000	7,000	10,000
15	100,000	7,000	100,000
16	2,000	10,000	3,000
17	2,000	10,000	3,000
18	2,000	10,000	3,000
19	2,000	10,000	3,000
20	2,000	100,000	3,000
21	7,000	3,000	8,000
22	7,000	3,000	8,000
23	7,000	3,000	8,000
24	7,000	3,000	8,000
25	7,000	3,000	8,000
26	10,000	8,000	10,000
27	10,000	8,000	10,000
28	10,000	8,000	10,000
29	10,000	8,000	10,000
30	1,000,000	8,000	250,000
31	3,000	10,000	3,000
32	3,000	10,000	3,000
33	3,000	10,000	3,000
34	3,000	10,000	3,000
35	3,000	250,000	3,000
36	8,000	3,000	8,000
37	8,000	3,000	8,000
38	8,000	3,000	8,000
39	8,000	3,000	8,000
40	8,000	3,000	8,000
41	10,000	8,000	10,000
42	10,000	8,000	10,000
43	10,000	8,000	10,000
44	10,000	8,000	10,000
45	100,000	8,000	100,000
46	3,000	10,000	3,000
47	3,000	10,000	3,000
48	3,000	10,000	3,000
49	3,000	10,000	3,000
50	3,000	100,000	3,000

INPUT -4- SECOND CYCLE REPLACEMENT
TO DETERMINE RESIDUAL VALUE

Option	Replacement Year	Cost
1	80	$1,000,000
2	55	$1,000,000
3	50	$1,000,000

OUTPUT - LEVEL 3 ANALYSIS

Year	OPTION 1		OPTION 2		OPTION 3	
	Cost	Pres.Value	Cost	Pres.Value	Cost	Pres.Value
0	600,000	600,000	10,000	10,000	1,000,000	1,000,000
1	3,000	2,830	10,000	9,434	2,000	1,887
2	3,000	2,670	10,000	8,900	2,000	1,780
3	3,000	2,519	10,000	8,396	2,000	1,679
4	3,000	2,376	10,000	7,921	2,000	1,584
5	3,000	2,242	1,000,000	747,258	2,000	1,495
6	8,000	5,640	2,000	1,410	7,000	4,935
7	8,000	5,320	2,000	1,330	7,000	4,655
8	8,000	5,019	2,000	1,255	7,000	4,392
9	8,000	4,735	2,000	1,184	7,000	4,143
10	8,000	4,467	2,000	1,117	7,000	3,909
11	10,000	5,268	7,000	3,688	10,000	5,268
12	10,000	4,970	7,000	3,479	10,000	4,970
13	10,000	4,688	7,000	3,282	10,000	4,688
14	10,000	4,423	7,000	3,096	10,000	4,423
15	100,000	41,727	7,000	2,921	100,000	41,727
16	2,000	787	10,000	3,936	3,000	1,181
17	2,000	743	10,000	3,714	3,000	1,114
18	2,000	701	10,000	3,503	3,000	1,051
19	2,000	661	10,000	3,305	3,000	992
20	2,000	624	100,000	31,180	3,000	935
21	7,000	2,059	3,000	882	8,000	2,353
22	7,000	1,943	3,000	833	8,000	2,220
23	7,000	1,833	3,000	785	8,000	2,094
24	7,000	1,729	3,000	741	8,000	1,976
25	7,000	1,631	3,000	699	8,000	1,864
26	10,000	2,198	8,000	1,758	10,000	2,198
27	10,000	2,074	8,000	1,659	10,000	2,074
28	10,000	1,956	8,000	1,565	10,000	1,956
29	10,000	1,846	8,000	1,476	10,000	1,846
30	1,000,000	174,110	8,000	1,393	250,000	43,528
31	3,000	493	10,000	1,643	3,000	493
32	3,000	465	10,000	1,550	3,000	465
33	3,000	439	10,000	1,462	3,000	439
34	3,000	414	10,000	1,379	3,000	414
35	3,000	390	250,000	32,526	3,000	390
36	8,000	982	3,000	368	8,000	982

37	8,000	926	3,000	347	8,000	926
38	8,000	874	3,000	328	8,000	874
39	8,000	824	3,000	309	8,000	824
40	8,000	778	3,000	292	8,000	778
41	10,000	917	8,000	734	10,000	917
42	10,000	865	8,000	692	10,000	865
43	10,000	816	8,000	653	10,000	816
44	10,000	770	8,000	616	10,000	770
45	100,000	7,265	8,000	581	100,000	7,265
46	3,000	206	10,000	685	3,000	206
47	3,000	194	10,000	647	3,000	194
48	3,000	183	10,000	610	3,000	183
49	3,000	173	10,000	575	3,000	173
50	3,000	163	100,000	5,429	3,000	163
Total Present Value:		$911,924		$923,527		$1,177,053
Residual Value :		($44,836)		($13,721)		$0
		===========		===========		===========
Net Present Value :		$867,088		$909,806		$1,177,053

1.7.4 FINANCIAL ANALYSIS (LEVEL 4)

INPUT -1- GENERAL

Name of Structure :	B.M BRIDGE 4	(max. 14 characters)
Site Number :	123-0004	(start with ')
Number of Options Considered :	3	(max 4)
Discount Rate :	0.06	(0.06 recommended)
Number of Rows to be entered :	50	(max 50)
Life Cycle for Replacement :	50	

INPUT -2- COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1 Deck Replacement	Treatment 2 O/lay, Water proof & Pave	Treatment 3 Mill & Repl. top course	Treatment 4 Repl. Water proof & Asph.
Design	50000	30000	5000	5000
Construction	700000	450000	80000	190000
Demolition				
Right-of-Way				
Approaches	50000	20000	5000	5000
Utilities				
Creek Diversion				
Detour	200000	100000	10000	50000
Other				
Total	$1,000,000	$600,000	$100,000	$250,000

INPUT -3- COST DATA FOR EACH OPTION

Year	Option 1	Option 2	Option 3
0	600,000	10,000	1,000,000
1	3,000	10,000	2,000
2	3,000	10,000	2,000
3	3,000	10,000	2,000
4	3,000	10,000	2,000
5	3,000	1,000,000	2,000
6	8,000	2,000	7,000
7	8,000	2,000	7,000
8	8,000	2,000	7,000
9	8,000	2,000	7,000
10	8,000	2,000	7,000
11	10,000	7,000	10,000
12	10,000	7,000	10,000
13	10,000	7,000	10,000
14	10,000	7,000	10,000
15	100,000	7,000	100,000
16	2,000	10,000	3,000
17	2,000	10,000	3,000
18	2,000	10,000	3,000
19	2,000	10,000	3,000
20	2,000	100,000	3,000
21	7,000	3,000	8,000
22	7,000	3,000	8,000
23	7,000	3,000	8,000
24	7,000	3,000	8,000
25	7,000	3,000	8,000
26	10,000	8,000	10,000
27	10,000	8,000	10,000
28	10,000	8,000	10,000
29	10,000	8,000	10,000
30	1,000,000	8,000	250,000
31	3,000	10,000	3,000
32	3,000	10,000	3,000
33	3,000	10,000	3,000
34	3,000	10,000	3,000
35	3,000	250,000	3,000
36	8,000	3,000	8,000
37	8,000	3,000	8,000
38	8,000	3,000	8,000
39	8,000	3,000	8,000
40	8,000	3,000	8,000
41	10,000	8,000	10,000
42	10,000	8,000	10,000
43	10,000	8,000	10,000
44	10,000	8,000	10,000
45	250,000	8,000	200,000
46	3,000	10,000	3,000
47	3,000	10,000	3,000
48	3,000	10,000	3,000
49	3,000	10,000	3,000
50	3,000	100,000	3,000

INPUT -4- SECOND CYCLE REPLACEMENT
TO DETERMINE RESIDUAL VALUE

Option	Replacement Year	Cost
1	80	$1,000,000
2	55	$1,000,000
3	50	$1,000,000

INPUT -5- TABLE FOR COST UNCERTAINTIES

Estimated Variation of cost (Vc)	Estimated Cost (Cn)	Probability of Occurrence (Pn)		
		Option 1	Option 2	Option 3
V1 = As Calculated	Cn	P1 =0.60	P1 =0.70	P1 =0.65
V2 = -10.00 %	0.90 Cn	P2 =0.15	P2 =0.10	P2 =0.10
V3 = 10.00 %	1.10 Cn	P3 =0.15	P3 =0.15	P3 =0.20
V4 = 20.00 %	1.20 Cn	P4 =0.10	P4 =0.05	P4 =0.05
		1.00	1.00	1.00

OUTPUT LEVEL -4- ANALYSIS

Year	OPTION 1		OPTION 2		OPTION 3	
	Cost	Pres.Value	Cost	Pres.Value	Cost	Pres.Value
0	600,000	600,000	10,000	10,000	1,000,000	1,000,000
1	3,000	2,830	10,000	9,434	2,000	1,887
2	3,000	2,670	10,000	8,900	2,000	1,780
3	3,000	2,519	10,000	8,396	2,000	1,679
4	3,000	2,376	10,000	7,921	2,000	1,584
5	3,000	2,242	1,000,000	747,258	2,000	1,495
6	8,000	5,640	2,000	1,410	7,000	4,935
7	8,000	5,320	2,000	1,330	7,000	4,655
8	8,000	5,019	2,000	1,255	7,000	4,392
9	8,000	4,735	2,000	1,184	7,000	4,143
10	8,000	4,467	2,000	1,117	7,000	3,909
11	10,000	5,268	7,000	3,688	10,000	5,268
12	10,000	4,970	7,000	3,479	10,000	4,970
13	10,000	4,688	7,000	3,282	10,000	4,688
14	10,000	4,423	7,000	3,096	10,000	4,423
15	100,000	41,727	7,000	2,921	100,000	41,727
16	2,000	787	10,000	3,936	3,000	1,181
17	2,000	743	10,000	3,714	3,000	1,114
18	2,000	701	10,000	3,503	3,000	1,051
19	2,000	661	10,000	3,305	3,000	992
20	2,000	624	100,000	31,180	3,000	935
21	7,000	2,059	3,000	882	8,000	2,353
22	7,000	1,943	3,000	833	8,000	2,220
23	7,000	1,833	3,000	785	8,000	2,094
24	7,000	1,729	3,000	741	8,000	1,976
25	7,000	1,631	3,000	699	8,000	1,864
26	10,000	2,198	8,000	1,758	10,000	2,198
27	10,000	2,074	8,000	1,659	10,000	2,074
28	10,000	1,956	8,000	1,565	10,000	1,956
29	10,000	1,846	8,000	1,476	10,000	1,846
30	1,000,000	174,110	8,000	1,393	250,000	43,528
31	3,000	493	10,000	1,643	3,000	493
32	3,000	465	10,000	1,550	3,000	465
33	3,000	439	10,000	1,462	3,000	439
34	3,000	414	10,000	1,379	3,000	414
35	3,000	390	250,000	32,526	3,000	390
36	8,000	982	3,000	368	8,000	982
37	8,000	926	3,000	347	8,000	926
38	8,000	874	3,000	328	8,000	874
39	8,000	824	3,000	309	8,000	824
40	8,000	778	3,000	292	8,000	778
41	10,000	917	8,000	734	10,000	917
42	10,000	865	8,000	692	10,000	865
43	10,000	816	8,000	653	10,000	816
44	10,000	770	8,000	616	10,000	770
45	250,000	18,163	8,000	581	200,000	14,530
46	3,000	206	10,000	685	3,000	206
47	3,000	194	10,000	647	3,000	194
48	3,000	183	10,000	610	3,000	183
49	3,000	173	10,000	575	3,000	173
50	3,000	163	100,000	5,429	3,000	163

Total Present Value: $922,822 $923,527 $1,184,318

FINANCIAL ANALYSIS (LEVEL 4) SUMMARY OF FINAL RESULTS

Total Present Value:	$922,822	$923,527	$1,184,318
Residual Value :	($44,836)	($13,721)	$0
	===========	===========	===========
Net Present Value :	$877,985	$909,806	$1,184,318
Net Present Value Adjusted for uncertainty in cost :	$895,545	$923,453	$1,208,004

APPENDIX A.1.1 - Present Value Analysis

Present values of two options considered for a bridge rehabilitation project are given by:

$$PV1 = \sum_{n=n_1}^{N} \frac{C_n}{(1+r)^n} \qquad \text{---- Option (1)}$$

$$PV2 = \sum_{n=n_1}^{N} \frac{C_n}{(1+r)^n} \qquad \text{---- Option (2}$$

PV_1 = present value for option 1.

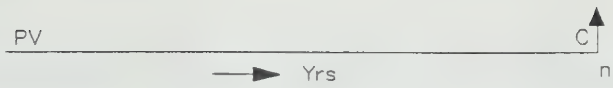
PV_2 = present value for option 2.

The Option which has the least present value is the preferred choice.

Fig. A.1.1 shows standard formulae for calculating present value for some typical expenditure patterns.

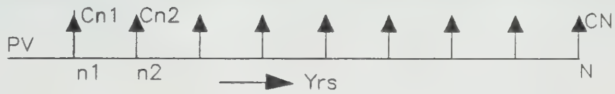
Equations 1, 2 and 3, in figure A.1.1, were used in developing the PRVAL Program. Other equations would be useful if a special type of problem is encountered and the analysis has to be carried out manually.

1. **Single Cost**



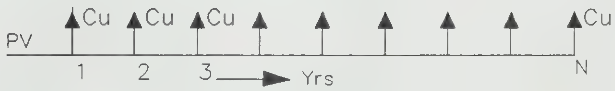
$$PV = C\left[\frac{1}{(1+r)^n}\right].....(1)$$

2. **Several Costs at Different Times**



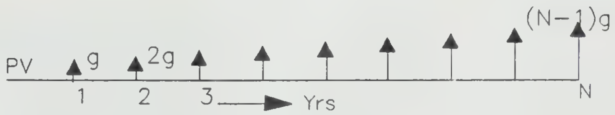
$$PV = \frac{C_{n1}}{(1+r)^{n1}} + \frac{C_{n2}}{(1+r)^{n2}} + ... + \frac{C_N}{(1+r)^N} = \sum_{n=n_1}^{N} \frac{C_n}{(1+r)^n}.....(2)$$

3. **Uniform Cost**



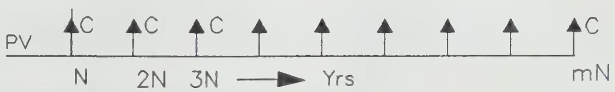
$$PV = C_u\left[\frac{1-(1+r)^{-N}}{r}\right].....(3)$$

4. **Uniform Gradient**



$$PV = \frac{g}{r}\left[\frac{1-(1+r)^{-N}}{r} - \frac{N}{(1+r)^N}\right].....(4)$$

5. **Perpetual Series**



$$PV = C\left[\frac{(1+r)^N}{(1+r)^N - 1}\right]......(5)$$

PRESENT VALUE CALCULATION BY DISCOUNTING

Fig. A.1.1

Appendix A.1.2 - Effects of Inflation

During inflation there is a difference between current and real prices, and similarly between nominal and real discount rates.

A.1.2.1 Same rate of inflation for general and construction costs.

If the rate of inflation f for general prices and construction costs is same then the relation between nominal cost and real cost is given by:

$$C_n = C_o(1+f)^n \text{.....(a1)}$$

where C_n is the nominal cost at year n, and C_o is the real cost at year o.

The relation between nominal and real discount rate is given by:

$$(1+R) = (1+r)(1+f) \text{ ..(b1)}$$

where R = nominal discount rate
r = real discount rate

for small values of r and f,

$$R = r+f$$

Substituting in equation (1) and (2) of Figure A.1.8.1

i) $$PV = \frac{C_N}{(1+R)^N} = \frac{C_o(1+f)^N}{[(1+r)(1+f)]^N} = \frac{C_o}{(1+r)^N}$$

ii) $$PV = \sum_{n=1}^{N} \frac{C_n}{(1+R)^n} = \sum_{n=1}^{N} \frac{C_o(1+f)^n}{[(1+r)(1+f)]^n} = \sum_{n=1}^{N} \frac{C_o}{(1+r)^n}$$

From the above it is evident that f has no effect on the analysis.

A.1.2.2 Different rates of inflation for general and construction costs.

If the general prices move at an inflation f and the construction costs move at f^1, equations (a^1) and (b^1) in A.1.2.1 would become:

$$C_n = C_o(1+f^1)^n \ldots (a^2)$$

and

$$(1+R) = (1+r)(1+f) \text{ ..... (b2)}$$

Substituting in equation (1) of Figure A.1.1

$$PV = \frac{C_N}{(1+R)^n} = \frac{C_o(1+f^1)^N}{[(1+r)(1+f)]^N} = \frac{C_o}{\left[(1+r)\frac{(1+f)}{(1+f^1)}\right]^N}$$

For small values of r , f and f^1,

$$PV = \frac{C_o}{[1+r-(f^1-f)]^N}$$

Where the adjusted discount rate = $r-(f^1-f)$

The difference between the discount rate r, and the adjusted discount rate is small.

APPENDIX A.1.3 - Assumed Life Spans

The assumed life spans of various treatments vary considerably for a number of reasons, and are not available for the new procedures. There is very little documented research data on which to base these life spans. The following assumed life spans are based on experiences of bridges on high volume freeways. The Engineer may use other values, based on his experience.

	Assumed Life, Years	
a. Asphalt		
1. Asphalt	15	
2. Mastic waterproofing and asphalt	15	
3. Hot applied rubberized waterproofing	30	
. Mill and replace top course of asphalt	15	
. Replace waterproofing and asphalt	30	
b. Concrete Deck slabs	Exposed Deck	Waterproof and pave
1. 0 mm to 75 mm deck slab - plain reinforcement, on precast boxes	5	10
2. 75 mm to 125 mm deck slab - plain reinforcement, on precast boxes	10	25
3. 125 mm to 180 mm deck slab on beams or girders		
. Plain reinforcement	10	25
. Top layer, epoxy coated	20	35
4. 180 mm to 225 mm deck slab on beams or girders		
. Plain reinforcement	20	35
. Top layer, epoxy coated	30	45
5. Solid thick deck slabs		
. Plain reinforcement	10	25
. Top layer, epoxy coated	30	45
6. Voided thick slabs		
. Plain reinforcement	10	25
. Top layer, epoxy coated	30	45
c Overlays		
1. Patch waterproof and pave		25
2. Latex modified concrete overlay	20	25
3. Normal slump concrete overlay	15	25
4. Conductive Bituminous overlay	20	-
5. Conc. overlay and conductive Bituminous overlay	25	-
6. Anode mesh, overlay, waterproof & pave	-	30

d. Coating Systems

	Assumed Life, Years
1. Alkyd System	10
2. High Build Alkyd System	10
3. Inorganic- Zinc / Vinyl System	20
4. Epoxy- Zinc / Vinyl System	20
5. Aluminum filled Epoximastic System	10
6. Hot Dip galvanizing	20
7. Zinc Metallizing	20

APPENDIX A.1.4 - Residual Value Analysis

At the end of N_1 years Option (1) may have reached its useful life, whereas option (2) has some residual life. This residual life can be translated into residual value. There are several methods availabe in calculating the residual value. The method used in this manual is the 2nd cycle replacement method, shown in Table A.1.4

Let the 2nd replacement of Option (1) be N_1 years.
and 2nd replacement of Option (2) be N_2 years.

Table A.1.4 Residual Value Analysis

Option	Year of Replacement (2nd cycle)	Replacement cost	Residual Years	Value at Year N_1	Differential Value (option 1 as base)	Residual Value at Year 0
1	N_1	C	O	C_1	C_{D1}	C_{R1}
2	N_2	C	N_2-N_1	C_2	C_{D2}	C_{R2}

Where r = Discount rate

C = Replacement cost in constant dollars

$C_1 = C$

$C_2 = C_1/(1+r)^{N2-N1}$

$C_{D1} = C_1 - C = 0$

$C_{D2} = C_2 - C$

$C_{R1} = O$

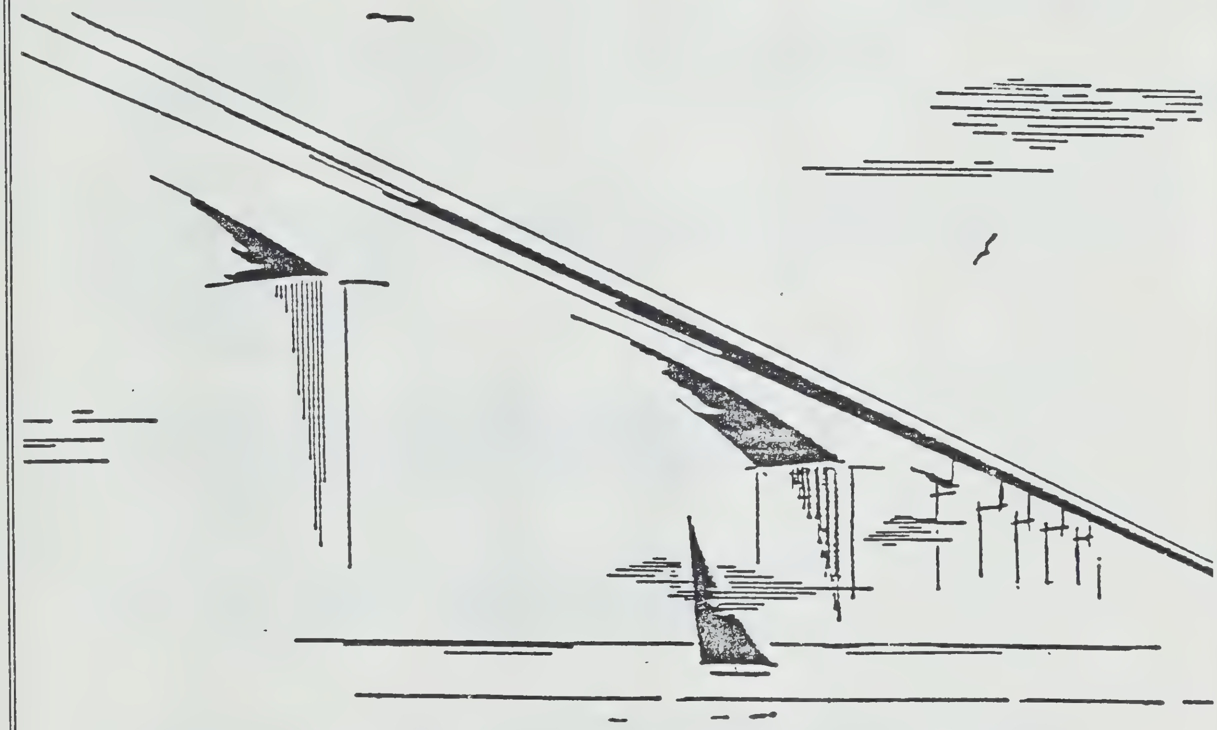
$C_{R2} = C_{D2}/(1+r)^{N1}$

Ontario

Ministry of
Transportation

Structural Office

Manual SO 11



Structural Financial Analysis Manual

PART 2 -- INCREMENTAL BENEFIT/COST RATIO ANALYSIS

-- PROJECT LEVEL --

Part 2 - Incremental Benefit/Cost ratio Analysis - Project Level

Part 2 Incremental Benefit/Cost Ratio Analysis - Project Level.

2.1 Scope

At the project level the incremental benefit/cost ratio analysis is used to determine cost-effective options and rank them according to their incremental benefit/cost ratios.

2.2 Principles of Incremental Benefit/Cost Ratio Analysis at the Project Level

The incremental benefit/cost ratio is the ratio of the additional benefits realized in moving from one improvement alternative to another, divided by the corresponding difference in costs. This method not only optimizes the selection of alternatives efficiently but also ranks the alternatives beginning with the one with the largest incremental benefit/cost ratio. As such, it can be used effectively at the project level.

The procedure is to list rehabilitation alternatives in the order of increasing costs and calculate the incremental benefit/cost ratio. Alternatives for which the incremental benefit/cost ratios fall below one are uneconomical and therefore discarded. Usually, as the cost increases the incremental benefit/cost ratio decreases. For unlimited budget the alternative with the most net benefit is the one with the largest initial cost and incremental benefit/cost ratio greater than one. When the budget is limited due to constraint, the order of preference is the order from the highest to the lowest incremental benefit/cost ratio. For further details of the theory of incremental benefit/cost analysis see Appendix A.2.1.

2.3 Project Level Analysis

At the project level the analysis may be carried out at two different levels.

a) Level (1) Analysis	Agency net benefits. (Considers only the agency benefits and costs.)
b) Level (2) Analysis	Agency and user net benefits. (Considers benefits and costs incurred by both the agency and the users.)

2.4 Parameters Required for Incremental Benefit/Cost Analysis

The following parameters are required for the incremental benefit/cost analysis.

- Agency costs
- Agency benefits
- User costs
- User benefits

2.4.1 Agency Cost

Agency costs are the same as the capital costs in Section 1.5.2, Part 1.

2.4.2 Agency Benefits

Maintenance and various types of rehabilitations extend the useful life of the bridge. These expenditures would postpone major costs for replacement. The difference between the present value of a rehabilitation option and that of a replacement option is the agency net benefit[6]. The agency net benefit plus the present value of the initial cost is the agency benefit.

If PV_1 is the present value of costs associated with a rehabilitation option, and PV_R is the present value of costs associated with the replacement option. Then,

$$\text{Agency net benefit} = PV_R - PV_1$$

$$\text{Agency benefit} = PV_R - PV_1 + C_1$$

Where C_1 is the discounted initial cost of the rehabilitation option .

2.4.3 User Costs

User costs are costs incurred by the user due to deficiencies or substandard conditions at the bridge. The following costs play an important role in determining user costs.

1) Accident Costs

Accident Costs result from bridge width or clearance restrictions and poor approach alignment and grades. Refer to Appendix A.2.2 for details and methodology for estimating accident costs for the different bridge widths.

2) Functional restriction costs

The functional restrictions such as load, clearance, etc. impose needs for detours for certain class of vehicles. This would increase the travel time and, hence, operating costs. This represents a major component of the user costs. The following unit prices are suggested for Ontario in determining user costs.

Vehicle Operating Cost for Trucks	- \$0.75/km
Time Cost	- \$25.00/hour
Average speed on detour	- 20 km per hour

For further details refer to Appendix A.2.3.

2.4.4 User Benefits

User benefits for a bridge rehabilitation option are the reduction in costs to the users due to the rehabilitation. In determining user benefits it is assumed that deficiencies will be eliminated when the bridge is replaced. figure 2.4.4 illustrates the method used in determining user benefits.

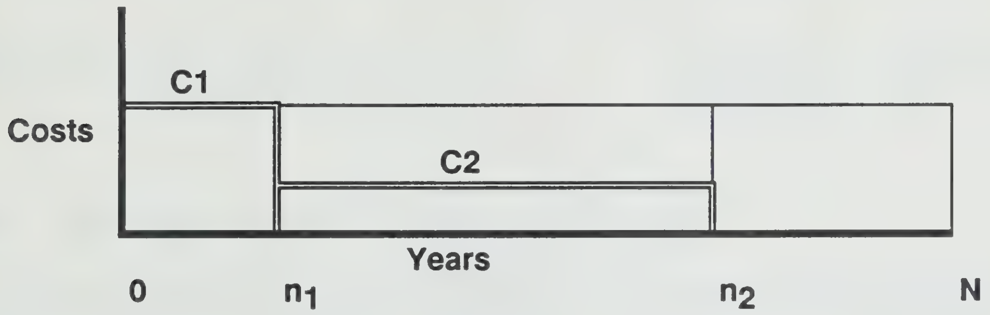


Fig 2.4.4 - User Benefits

Where

- N - the period in years considered for life cycle analysis
- C_1 - the annual user costs before the rehabilitation.
- n_1 - the year of rehabilitation
- C_2 - the annual user costs after the rehabilitation
- n_2 - year of replacement

The user benefit is the present value of the annual benefits of:

$(C_1 - C_2)$	from n_1 to n_2, and
C_1	from n_2 to N.

USER BENEFIT $$= \left\{ \sum_{n=n_1}^{n_2} \frac{C_1 - C_2}{(1+r)^n} \right\} + \left\{ \sum_{n=n_2}^{N} \frac{C_1}{(1+r)^n} \right\}$$

$$= (C_1 - C_2) \left\{ \frac{1-(1+r)^{(n_2-n_1)}}{r} \right\} \frac{1}{(1+r)^{n_1}} + C_1 \left\{ \frac{1-(1+r)^{(N-n_2)}}{r} \right\} \frac{1}{(1+r)^{n_2}}$$

2.5 Incremental Benefit/Cost Ratio Analysis Using COSBEN Program

COSBEN is a program developed to perform incremental benefit-cost analysis for bridge rehabilitation projects using Lotus 1-2-3, Version 2.01, on a worksheet format. There are 2 options available to perform the above analysis.

COSBEN01.WK1 - Level I Analysis	Considers only agency costs and benefits .
COSBEN02.WK1 - Level 2 Analysis	Considers both agency and user costs and benefits .

2.5.1 Running COSBEN From Floppy Disk Drive

COSBEN01.WK1, COSBEN02.WK1 files are in a directory called COSBEN on the floppy disk supplied with this manual. Load Lotus 1-2-3, version 2.01 and retrieve COSBEN directory and choose the files as required.

2.5.2 Running COSBEN From Hard Disk Drive

Create a subdirectory called COSBEN and copy the two files COSBEN01.WK1 and COSBEN02.WK1 into this subdirectory. Load Lotus 1-2-3, version 2.01 and retrieve COSBEN to choose the required file.

2.5.3 INPUT SCREENS FOR COSBEN PROGRAM (PROJECT LEVEL)

INSTRUCTIONS TO USER:

During the analysis if you wish to access Instructions to user screen or input tables to make changes, do the following :

INSTRUCTIONS TO USER:	alt.h
INPUT 1	alt.i
INPUT 2	alt.j
INPUT 3	alt.k
INPUT 4	alt.l
INPUT 5	alt.m
INPUT 6	alt.n
Print	alt.p

- alt.a builds up the required Input tables 3,4 & 5 from data in INPUT 1
- Do not press alt.a to do revisions, unless the number of options are different.

INPUT -1- GENERAL

Region :		Bridge #:
District :		(start with ^)
Name of Structure	:	(max. 14 characters)
Site Number	:	(start with ')
Number of Options	:	(max 6)
Discount Rate	:	(0.06 recommended)
Number of Rows of entries	:	(max 50)
Time period	:	(normally 50 years)

COMMENTS :

- This screen is common to both levels.
- The Discount Rate must be expressed in decimal form to two places.
- Number of rows to be entered. These are the rows to be entered in INPUT 3.

INPUT -2- COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Design				
Construction				
Demolition				
Right-of-Way				
Approaches				
Utilities				
Creek Divers				
Detour				
Other				
Total	$0	$0	$0	$0

COMMENTS :

- This table is common to both levels.
- Under each Treatment describe the type of rehabilitation or replacement.
  (2 rows are available for this.)
- Enter cost estimates for each treatment under the headings shown.
  These headings were chosen to ensure all costs are accounted for.
- Totals are calculated by the program automatically.

INPUT 3 - FIRST COST DATA

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Year						
Cost						

Comments:

-Intial cost for each option is entered against the corresponding year at which it occurs.

-If the initial expenditure is immediate then enter year as 0.

INPUT 4 - LIFE CYCLE COST DATA

Year	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6

COMMENTS :

- The costs are obtained from Input 2.
- Enter the year and the costs which occur in that year for each option.
- The table size will vary according to the number of rows and
  the number of options entered in Input 1.

INPUT -5- SECOND CYCLE REPLACEMENT
TO DETERMINE RESIDUAL VALUE

Options	Replaceme Year	Cost
1		
2		
3		
4		
5		
6		

COMMENTS :

- Enter Second Cycle Replacement costs in constant dollar terms.
  i.e. the second cycle replacement COST is the same for each option, but the second cycle replacement YEAR is different.

INPUT 6 - USER COST DATA

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
C1						
C2						
n1						
n2						
N						

COMMENTS

- Input 6 is required only for Level 2 analysis.
- C1 - the annual user costs associated with the bridge.
- C2 - user costs after rehabilitation.
- n1 - the year of rehabilitation.
- n2 - year of replacement, reduces the annual user costs to zero.
- N - the period in years considered for life cycle analysis.

2.6 Examples of Incremental benefit/cost Analysis

The example is the selection of the most cost-effective option for a rehabilitation project. The project engineer has come up with the following data and options as part of his engineering assessment.

a) Time period to be considered - 50 years

b) The four options to be considered are as follows:

Option (1)	Deck replacement now. Year 15 - Mill top surface of asphalt. Year 30 - Replace waterproof and pave. Year 45 - Mill top surface of asphalt.
Option (2)	Cathodic protection with anode mesh and concrete overlay and waterproof. This will extend the life by 30 years. Year 15 - Mill top surface of asphalt. Year 30 - Replace deck slab. Year 45 - Mill top surface of asphalt.
Option (3)	Overlay, waterproof and pave. This will extend the life by 25 years. Year 15 - Mill top surface of asphalt. Year 25 - Replace deck slab. Year 40 - Mill top surface of asphalt.
Option (4)	Minor rehabilitation to extend the life by 5 years. Year 5 - Replace deck slab. Year 20 - Mill top surface of asphalt. Year 35 - Replace waterproof and pave. Year 50 - Mill top surface of asphalt.

c) The agency and user costs are given in Table 2.6(a) and 2.6(b)

Table 2.6(a) Life cycle cost data

Yrs	Option 1	Option 2	Option 3	Option 4
0	2,000,000	1,200,000	900,000	300,000
5				2,000,000
15	200,000	200,000	200,000	
20				200,000
25			2,000,000	
30	600,000	2,000,000		
35				600,000
40			200,000	
45	200,000	200,000		
50				200,00

Table 2.6(b) User cost data

	Option 1	Option 2	Option 3	Option 4
C_1	20000	20000	20000	20000
C_2	0	4000	6000	20000
n_1	0	0	0	0
n_2	0	30	25	5
N	50	50	50	50

The incremental benefit/cost ratio analysis is performed at level 1 and level 2 as shown in sections 2.6.1 and 2.6.2

2.6.1 INCREMENTAL BENEFIT-COST RATIO ANALYSIS.

LEVEL 1 - AGENCY BENEFIT-COST ANALYSIS.

INPUT -1- GENERAL

Region :	XYZ	Bridge #:	2
District :	99	(start with ^)	

Name of Structure	: ABCD01	
Site Number	: 03-0011	(start with ')
Number of Options	: 4	(max 6)
Discount Rate	: 0.06	(0.06 recommended)
Number of Rows of entries	: 8	(max 50)
Life Cycle for Replacement	: 50	

INPUT -2- COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1 Bridge Replacement	Treatment 2 Deck Repl. & Sub. Struc.	Treatment 3 O'lay, w.p Sub. Struc.	Treatment 4 Cath. prot. Sub. Struc.
Design	500000	100000	30000	100000
Construction	2750000	1000000	400000	750000
Demolition	500000	100000	50000	100000
Right-of-Way				
Approaches	250000	20000	20000	50000
Utilities				
Creek Divers				
Detour				
Other				
Total	$4,000,000	$1,220,000	$500,000	$1,000,000

INPUT 3 - FIRST COST DATA

	Option 1 Replacement	Option 2	Option 3	Option 4
Year	0	0	0	0
Cost	4000000	1220000	500000	1000000

INPUT 4 - LIFE CYCLE COST DATA

Year	Option 1 Replacement	Option 2	Option 3	Option 4
0	4000000	1220000	500000	1000000
5			4000000	
10				4000000
15	300000	4000000		
20			300000	
30	200000	300000		300000
40			200000	
50		200000		200000

INPUT -5- SECOND CYCLE REPLACEMENT
TO DETERMINE RESIDUAL VALUE

Options	Replaceme Year	Cost
1	50	4000000
2	65	4000000
3	55	4000000
4	60	4000000

OUTPUT -LEVEL 1.
================

PRESENT VALUE:

	Option 1	Option 2	Option 3	Option 4
Present Value	$4,160,002	$2,952,151	$3,602,019	$3,296,670
Residual Value	$0	($126,543)	($54,884)	($95,896)
Total Present Value	$4,160,002	$2,825,608	$3,547,135	$3,200,774

AGENCY BENEFITS

OPTIONS	NET BENEF (Agency)	COST (Agency)	BENEFIT (Agency)
1	0	4000000	4000000
2	1334393	1220000	2554393
3	612867	500000	1112867
4	959228	1000000	1959228

INCREMENTAL BENFIT-COST RATIO

OPTIONS	NET BENE. (Agency)	COST (Agency)	BENEFIT (Agency)	I.C	I.B	I.B/I.C
3	612867	500000	1112867	500000	1112867	2.23
4	959228	1000000	1959228	500000	846361	1.69
2	1334393	1220000	2554393	220000	595166	2.71
1	0	4000000	4000000	2780000	1445607	0.52

COST-EFFECTIVE OPTIONS

OPTIONS	NET BENE. (Agency)	COST (Agency)	BENEFIT (Agency)	I.C	I.B	I.B/I.C
3	612867	500000	1112867	500000	1112867	2.23
4	959228	1000000	1959228	500000	846361	1.69
2	1334393	1220000	2554393	220000	595166	2.71

OPTIONS DELETED

OPTIONS	NET BENE. (Agency)	COST (Agency)	BENEFIT (Agency)	I.C	I.B	I.B/I.C
1	0	4000000	4000000	2780000	1445607	0.52

ADJUSTED I.B/I.C

OPTIONS	NET BENE. (Agency)	COST (Agency)	I.B/I.C	I.B/I.C Adjusted
3	612867	500000	2.23	2.23
4	959228	1000000	1.69	1.69
2	1334393	1220000	2.71	2.00

ORDER OF PRIORITY (with unlimited budget)

For unlimited budget the Engineer should choose the option with largest first cost, and I.B/I.C >1.

ORDER OF PRIORITY (with limited budget)

Order of Priority	OPTIONS	NET BENEF	COST (AGENCY)	I.B/I.C
1	3	612867	500000	2.23
2	2	1334393	1220000	2.00
3	4	959228	1000000	1.69
4	1	0	4000000	0.52

2.6.2 INCREMENTAL BENEFIT-COST RATIO ANALYSIS.

LEVEL 2 - AGENCY & USER BENEFIT-COST ANALYSIS.

INPUT -1- GENERAL

Region : XYZ Bridge #: 1
District : 99 (start wi

Name of Structure	: ABCD02	(max. 14 character
Site Number	: 03-0012	(start with ')
Number of Options	: 4	(max 6)
Discount Rate	: 0.06	(0.06 recommended)
Number of Rows of entries	: 7	(max 50)
Life Cycle for Replacement	: 50	

INPUT -2- COST ESTIMATE FOR EACH TREATMENT

Item	Treatment 1 Deck Replace	Treatment 2 Resurfacing	Treatment 3 Patch, w.p & pave	Treatment 4 Minor Repair
Design	75000	20000	30000	
Construction	850000	150000	320000	10000
Demolition	50000	20000	35000	
Right-of-Way				
Approaches	25000	10000	15000	
Utilities				
Creek Divers				
Detour				
Other				
Total	$1,000,000	$200,000	$400,000	$10,000

INPUT 3 - FIRST COST DATA

	Option 1	Option 2	Option 3	Option 4
Year	0	0	0	0
Cost	1000000	200000	300000	10000

INPUT 4 - LIFE CYCLE COST DATA

Year	Option 1	Option 2	Option 3	Option 4
0	1000000	200000	300000	10000
5				1000000
15	100000	1000000		
20			1000000	100000
30	200000	100000		
35			100000	200000
45		200000		

INPUT -5- SECOND CYCLE REPLACEMENT
TO DETERMINE RESIDUAL VALUE

Options	Replaceme Year	Cost
1	50	1000000
2	65	1000000
3	70	1000000
4	55	1000000

INPUT 6 - USER COST DATA

	Option 1	Option 2	Option 3	Option 4
C1	10000	10000	10000	10000
C2	0	6000	4000	0
n1	0	0	0	5
n2	0	15	30	5
N	50	50	50	50

OUTPUT -LEVEL 2.
================

AGENCY COST :

	Option 1	Option 2	Option 3	Option 4
Present Value	$1,076,549	$649,206	$624,815	$814,460
Residual Value	$0	($31,636)	($37,361)	($13,721)
	$1,076,549	$617,570	$587,454	$800,739

TOTAL BENEFITS

OPTIONS	NET BENEF (Agency)	COST (Agency)	BENEFIT (User)	BENEFIT (Total)
1	0	1000000	157619	1157619
2	458978	200000	99345	758323
3	489094	300000	102559	891654
4	275810	10000	115495	401305

INCREMENTAL BENEFIT-COST RATIO

OPTIONS	NET BENEF (Agency)	COST (Agency)	BENEFIT (User)	BENEFIT (Total)	I.C	I.B	I.B/I.C
4	275810	10000	115495	401305	10000	401305	40.13
2	458978	200000	99345	758323	190000	357019	1.88
3	489094	300000	102559	891654	100000	133330	1.33
1	0	1000000	157619	1157619	700000	265965	0.38

COST-EFFECTIVE OPTIONS

OPTIONS	NET BENEF (Agency)	COST (Agency)	BENEFIT (User)	BENEFIT (Total)	I.C	I.B	I.B/I.C
4	275810	10000	115495	401305	10000	401305	40.13
2	458978	200000	99345	758323	190000	357019	1.88
3	489094	300000	102559	891654	100000	133330	1.33

OPTIONS DELETED

OPTIONS	NET BENEF	COST (Agency)	BENEFIT (User)	BENEFIT (Total)	I.C	I.B	I.B/I.C
1	0	1000000	157619	1157619	700000	265965	0.38

ADJUSTED I.B/I.C

OPTIONS	NET BENEF (Age+Use)	COST (Agency)	I.B/I.C	I.B/I.C (adjusted
4	391305	10000	40.13	40.13
2	558323	200000	1.88	1.88
3	591654	300000	1.33	1.33

ORDER OF PRIORITY (with limited budget)

For unlimited budget the Engineer should choose the option with largest first cost, and I.B/I.C >1.

ORDER OF PRIORITY (with limited budget)

Order of Priority	OPTIONS	NET BENEF (Age+Use)	COST (Agency)	I.B/I.C
1	4	391305	10000	40.13
2	2	558323	200000	1.88
3	3	591654	300000	1.33
4	1	157619	1000000	0.38

A.2.1 Theory of Incremental Benefit/Cost Ratio Analysis[6]

The incremental benefit/cost ratio is the ratio of the additional benefits realized in moving from one improvement alternative to another, divided by the corresponding difference in costs. This method not only optimizes the selection of alternatives efficiently but also ranks the projects beginning with the most net beneficial. It is used both at the project and network levels.

Figure A.2.1(a) shows the total benefit and first cost curves plotted for the various alternatives for a bridge. Initially, the increment of benefit is higher than the increment of cost. As costs increase the incremental benefits decline and are less than the incremental costs. The slopes of these benefits and first cost curves support the theory of diminishing returns. For a particular level of improvement there exist points on the benefit and cost curves, where the slopes of the two curves are equal, ie. **I.B = I.C.** At this level of improvement the net benefit is a maximum. This is evident from figure A.2.1(b). Any option below this level where **I.B/I.C > 1** is a desirable option.

The procedure is to list rehabilitation alternatives in the order of increasing costs and calculate the incremental benefit/cost ratios. One of the alternatives considered should be the replacement alternative. If one of the alternatives is do nothing, then a reasonable sum for maintenece cost should be identified as the first cost. Alternatives for which the incremental benefit/cost ratios fall below one are discarded. Usually, as the level of cost increases the incremental benefit/cost ratio I.B/I.C decreases. However, if the ratio I.B/I.C should increase with increase in cost then that particular option is ignored and the incremental benefit/cost ratio is recalculated by considering the remaining options. This is called the adjusted incremental benefit/cost ratio. This adjustment is is not repeated if the ratio I.B/I.C should still increase. The options are sorted in descending order of I.B/I.C. For an unlimited budget the most net beneficial alternative is the one with the largest initial cost and whose incremental benefit/cost ratio is greater than or equal to one. For a limited budget the preference is the option which could be carried out with the available budget and whose incremental benefit/cost ratio is > 1.

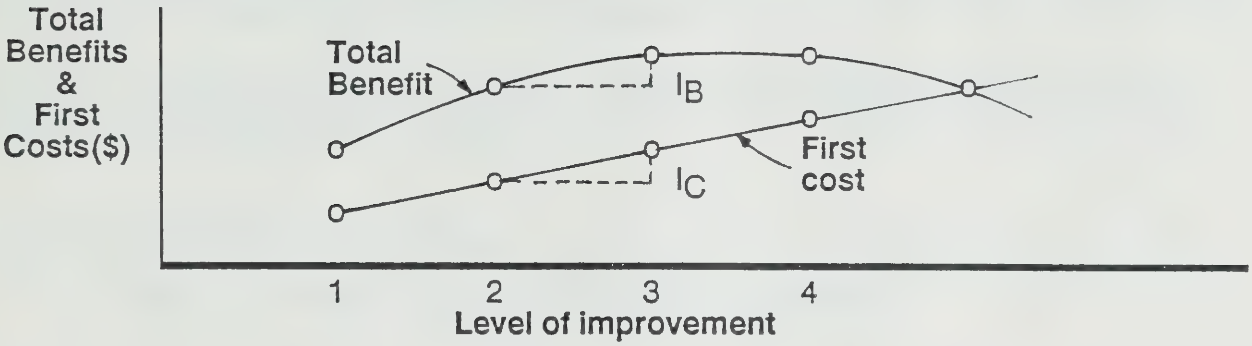


Fig A.2.1(a). Total benefits and first cost.

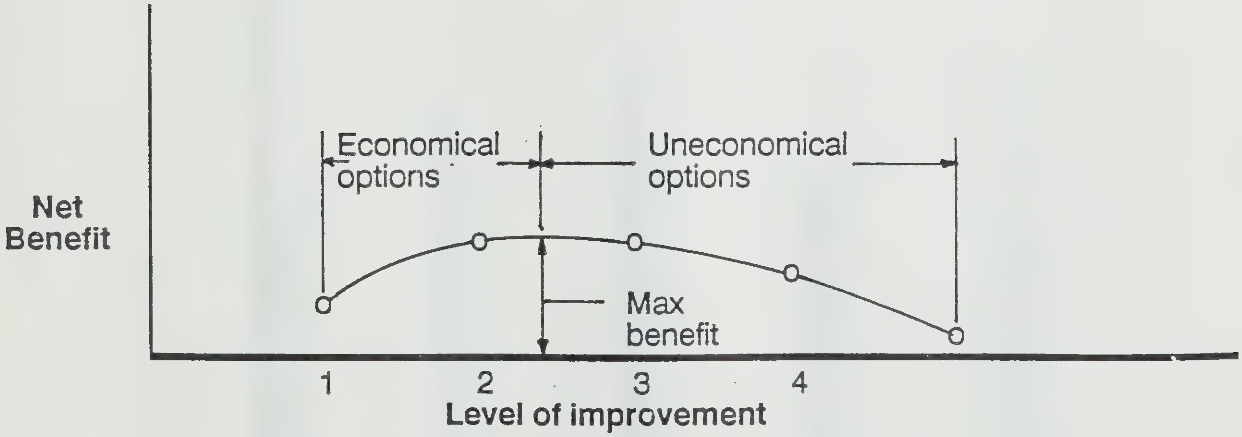


Fig A.2.1(b) Net benefits.

A 2.2 Costs Associated with Reduction in Accident Rates.

The reduction in the number of accidents due to a certain type of improvement is used as a measure of user benefit for that type of improvement.

The effect of bridge width on accident rates is shown on figure A.2.2. These data were compiled from statistics from some states in U.S.A[7]. In the absence of local data these accident rates may be used in the analysis.

Annual User Benefits (from widening)

= (change in accident rate)*(ADT)*(365)*(Accident cost)

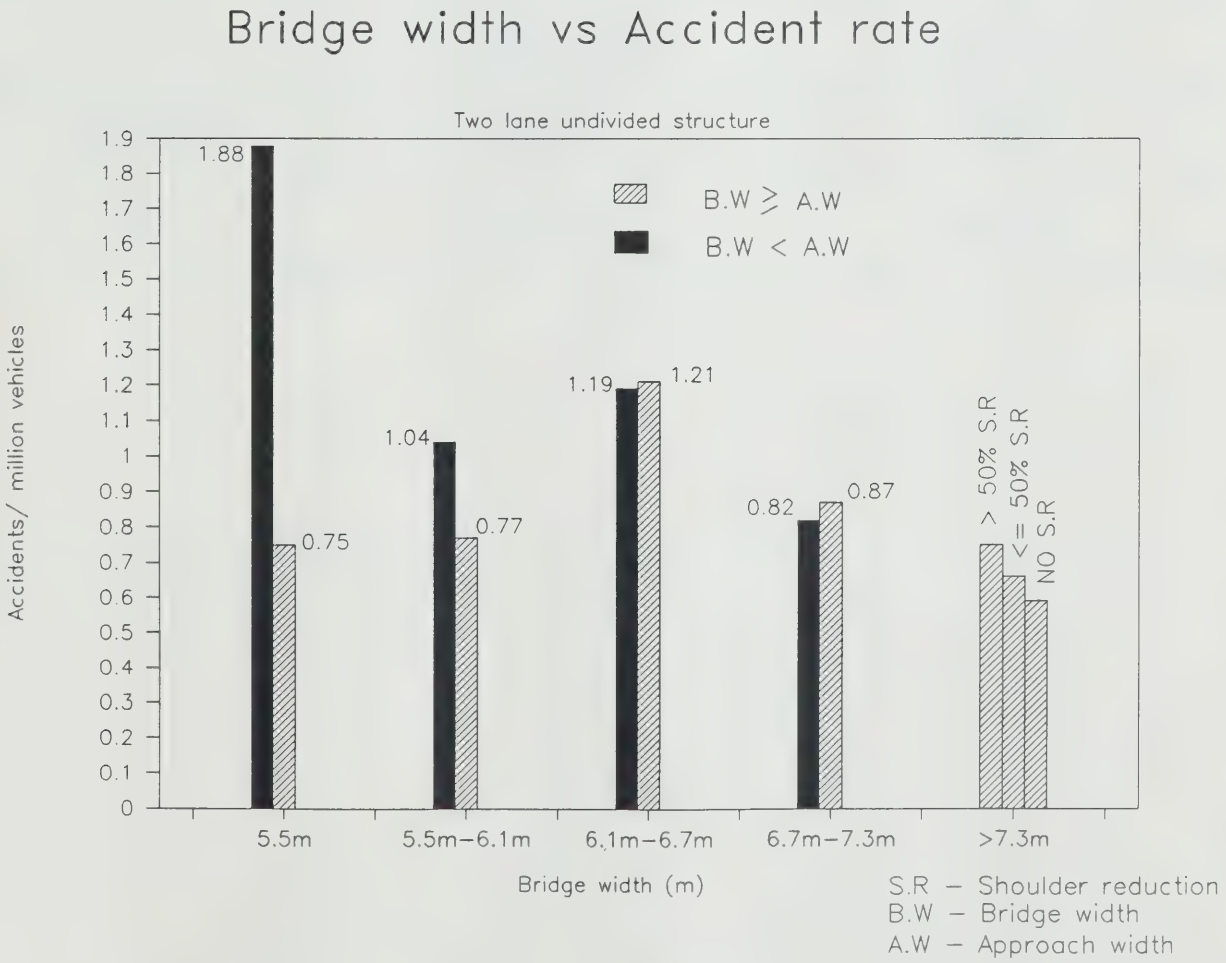


FIG A.2.2

The accident costs depend on the severity of the accident. It is very difficult to place a dollar value on accidents. The dollar value placed on different types of accidents is crucial in estimating user benefits.

Several attempts have been made to quantify these. The two common methods are

a) Human capital approach

b) Willingness to pay approach

Table A.2.2 gives accident costs estimated by both methods. These figures are adapted from a study done in United States[8]. They are adjusted to 1988 Canadian dollars.

Table A.2.2 Estimated Accident Costs.

	Willingness-to-pay Approach	Human capital Approach
Type of accident	Cost per accident	Cost per accident
Fatal	$1.900,000	$700,000

A 2.3 Costs Associated with Functional Restrictions.

User costs associated with a functional restriction are determined by the length of time that the restriction has existed. If a bridge is subjected to functional restrictions due to substandard conditions, such as load or clearance restrictions, then there is a need to detour for certain classes of vehicles.

The example given below illustrates the calculation of user costs.

- Average daily truck traffic (ADTT)	= 1000
- Vehicle operating cost	= \$0.75 per km
- Operator cost per hour	= \$25
- Length of detour	= 2.5 Km
- Average speed on the detour	= 20 km per hour
- Percentage of the trucks that must use the detour	= 15%

User cost per km	= \$ { 25/20 + 0.75 }
	= \$ 2.00
User cost per year	= \$ {1000}*{0.15}*{2}*{2.5}*{365}
	= \$ 273,750

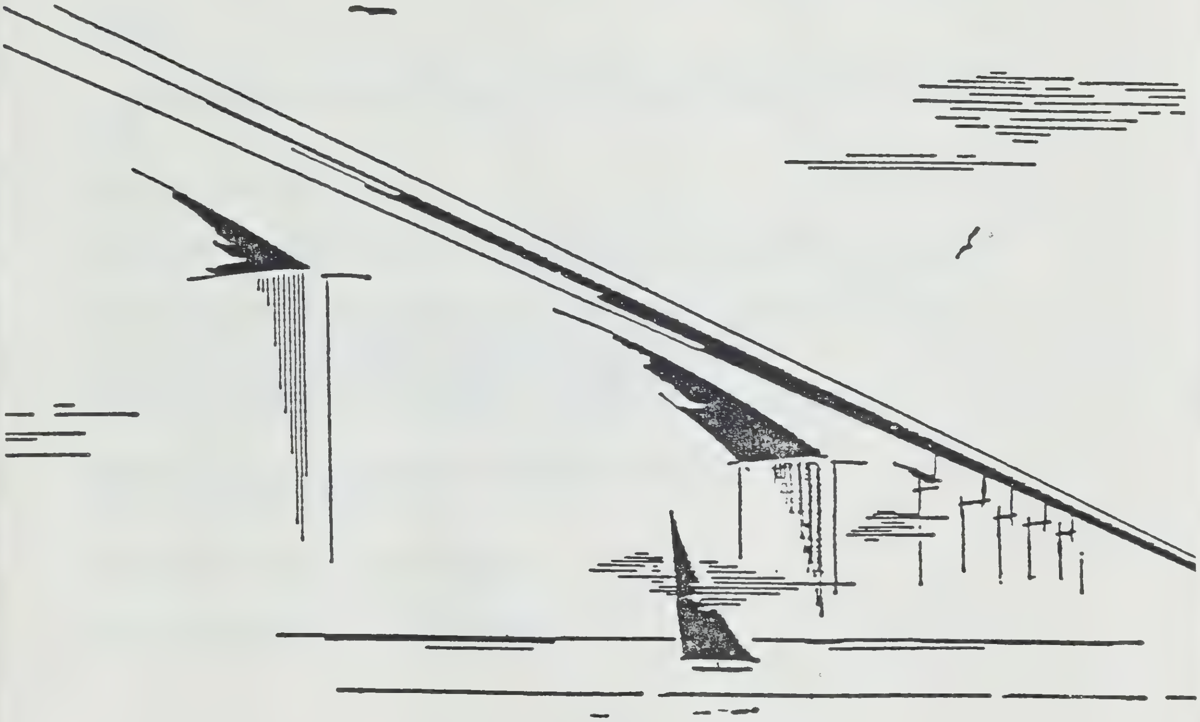
Some rehabilitation options will partly or wholly remove this deficiency. User cost saving resulting from a rehabilitation option is equal to the annual user benefit.

Ontario

Ministry of
Transportation

Structural Office

Manual SO 11



Structural Financial Analysis Manual

PART 3 -- INCREMENTAL BENEFIT/COST RATIO ANALYSIS

-- NETWORK LEVEL --

Part 3 - Incremental Benefit/Cost ratio Analysis - Network Level

3.1 Scope

At the Network Level the Incremental Benefit/Cost Ratio Analysis is used to allocate resources among bridges at different locations. Bridges are ranked in priority in descending order of incremetal benefit/cost ratios.

3.2 Principles of Incremental Benefit/Cost Ratio Analysis at Network level.

At the network level several bridges are considered in determining an order of priority in which funds should be allocated to them. The goal is to select a combination of bridge improvements that yields the maximum net benefit within an available budget.

Cost-effective options at the project level at each location are used as input for the net-work analysis. These are sorted according to decreasing order of their incremental benefit-cost ratios. The alternatives are chosen from the highest to the lowest incremental benefit-cost ratios. The corresponding costs are accumulated to determine which alternatives should be included in the budget.

3.3 Network Level Analysis

At the network level the analysis may be carried out at two different levels.

a) Level (1) Analysis — With limited budget.

b) Level (2) Analysis — With unlimited budget.

3.4 Parameters Required For Incremental Benefit/Cost Ratio Analysis

The parameters for network analysis are the same as those for project level analysis given in section 2.4.

3.5 Incremental Benefit/Cost Ratio Analyis Using COSBEN Program

COSBEN03.WK1 is a program developed to perform the incremental benefit-cost ratio analysis for bridge rehabilitation projects at the network level using Lotus 1-2-3, Version 2.01, on a worksheet format. The analysis can be performed either for limited or unlimited budgets. Both options use the same program. The only difference is that the input for unlimited budget is a large number, ($ 1,000,000,000).

Incremental benefit/cost ratios that are equal to or greater than one for each bridge, calculated at the project level, are used as input to COSBEN03.WK1 program to carry out the network analysis. The Engineer must decide if user benefits are to be considered in the

network analysis. If user benfits are to be considered at the network level, then the project level analysis should include user benfits for all bridges. User benfits for bridges with no functional restrictions will be zero.

3.5.1 Running COSBEN From Floppy Disk Drive

COSBEN03.WK1 is in the same COSBEN directory which contains COSBEN01.WK1 and COSBEN02.WK1 files. This floppy disk is supplied with the manual. Load Lotus 1-2-3, version 2.01 and retrieve COSBEN directory and choose the files as required.

3.5.2 Running COSBEN From Hard Disk Drive

Create a subdirectory called COSBEN and copy COSBEN03.WK1 together with the two files COSBEN01.WK1 and COSBEN02.WK1 into this subdirectory. Load Lotus 1-2-3, version 2.01 and retrieve COSBEN to choose the required file.

3.5.3 INPUT SCREENS FOR COSBEN PROGRAM (NETWORK LEVEL)

INSTRUCTIONS TO USER:

During the analysis if you wish to access Instructions to user screen, input tables to make changes or print, do the following :

INSTRUCTIONS TO USER:	alt.h
INPUT 1	alt.i
INPUT 2	alt.j
INPUT 3	alt.k
Print	alt.p

- alt.a builds up the required Input tables 2 & 3 from data in INPUT 1
- Do not press alt.a to do revisions, unless the number of options are different.

INPUT -1- GENERAL

Region	:	
Number of Bridges	:	
Total # of Options	:	
Available Budget	:	(For unlimited budget input 10,000,000,000)

COMMENTS :

- This screen is common to both levels.
- If you wish to make changes in the above data type alt-i.

INPUT - 2 - BRIDGES

Site #	Bridge #

- Bridge # is automatically entered when alt.a is executed.
- Enter the site # with a (').

INPUT - 3 DATA from COSBEN01.WK1 or COSBEN02.WK1

Bridge #	Options #	Net Benefit	First Cost	I.B/I.C

- Copy the data from the order of priority output from COSBEN01 or COSBEN02 to enter the values in the respective columns for each bridge.

3.6 Example of Incremental/ benefit cost ratio analysis at Network level

For a budget limitation of $7,000,000, prioritize the various options for the eight bridges shown in Table 3.6. The data shown in Table 3.6 is obtained from the output of COSBEN02.WK1. Some of the options considered at the project level analysis have been discarded as uneconomical options. For example, five options were considered for bridge #1 , options 1 and 3 were discarded since they were uneconomical.

Table 3.6 - Input Data

Bridge #	Options	Net benefits (in 1000' $)	First cost (in 1000' $)	I.B/I.C
1	2	950	100	10.5
	4	1,150	500	2.5
	5	1,850	2,000	1.2
2	2	1,100	2,000	6.5
	3	1,925	750	2.5
3	5	800	250	4.2
	2	1,400	500	3.4
	4	1,580	800	1.6
4	2	1,640	200	9.2
	4	2,660	500	4.4
	5	2,810	1,000	1.3
5	2	2,500	200	12.5
	3	3,620	500	5.4
	5	4,520	750	4.6
6	3	2,720	400	6.8
	2	3,020	600	4.5
	4	3,680	900	3.2
7	2	1,975	250	7.7
	3	2,425	450	4.5
	5	2,650	1,200	1.3
8	2	4,680	300	15.6
	3	5,395	650	3.9
	5	5,695	850	2.5
	4	5,845	1,600	1.2

The network analysis is performed and is given in section 3.6.1.

3.6.1 INCREMENTAL BENFIT-COST RATIO ANALYSIS. - NET WORK ANALYSIS

INPUT -1- GENERAL

Region	:	CENTRAL
Number of Bridges	:	8
Total # of Options	:	24
Available Budget	:	7,000,000

INPUT -2- BRIDGES

Site #	Bridge #
12-001	1
23-546	2
45-234	3
03-123	4
14-465	5
07-243	6
12-567	7
09-193	8

INPUT -3- DATA from COSBEN01.WK1 or COSBEN02.WK1

Bridge #	Options	Net Benefit	First Cost	I.B/I.C
1	2	950000	100000	10.5
1	4	1550000	500000	2.5
1	5	1850000	2000000	1.2
2	2	1100000	200000	6.5
2	3	1925000	750000	2.5
3	5	800000	250000	4.2
3	2	1400000	500000	3.4
3	4	1580000	800000	1.6
4	2	1640000	200000	9.2
4	4	2660000	500000	4.4
4	5	2810000	1000000	1.3
5	2	2300000	200000	12.5
5	3	3620000	500000	5.4
5	5	4520000	750000	4.6
6	3	2320000	400000	6.8
6	2	3020000	600000	4.5
6	4	3680000	900000	3.2
7	2	1725000	250000	7.9
7	3	2425000	450000	4.5
7	5	2650000	1200000	1.3
8	2	4380000	300000	15.6
8	3	5395000	650000	3.9
8	5	5695000	850000	2.5
8	4	5845000	1600000	1.2

OUTPUT - NETWORK ANALYSIS
=========================

COST-EFFECTIVE OPTIONS:

Bridge #	Options	Net Benefit	First Cost	I.B/I.C
8	2	4380000	300000	15.6
5	2	2300000	200000	12.5
1	2	950000	100000	10.5
4	2	1640000	200000	9.2
7	2	1725000	250000	7.9
6	3	2320000	400000	6.8
2	2	1100000	200000	6.5
5	3	3620000	500000	5.4
5	5	4520000	750000	4.6
7	3	2425000	450000	4.5
6	2	3020000	600000	4.5
4	4	2660000	500000	4.4
3	5	800000	250000	4.2
8	3	5395000	650000	3.9
3	2	1400000	500000	3.4
6	4	3680000	900000	3.2
1	4	1550000	500000	2.5
8	5	5695000	850000	2.5
2	3	1925000	750000	2.5
3	4	1580000	800000	1.6
7	5	2650000	1200000	1.3
4	5	2810000	1000000	1.3
1	5	1850000	2000000	1.2
8	4	5845000	1600000	1.2

Cost-Effective Projects With Available Budget

Order of Priority	Site #	Bridge #	Options #	Net Benefit	First Cost	I.B/I.C
1	14-465	5	5	4520000	750000	4.6
2	07-243	6	4	3680000	900000	3.2
3	12-001	1	4	1550000	500000	2.5
4	09-193	8	5	5695000	850000	2.5
5	23-546	2	3	1925000	750000	2.5
6	45-234	3	4	1580000	800000	1.6
7	12-567	7	5	2650000	1200000	1.3
8	03-123	4	5	2810000	1000000	1.3

Budget spent $6,750,000
Balance $250,000

3.7 Regional Network Level Analysis

Each region can carry out the regional network level analysis, using the data for bridges in its own region without input from the other regions.

3.8 Provincial Network Level Analysis

The Provincial network level analysis would have to be carried out at the Head Office by the Bridge Management Section or by the Capital Highway Planning Office. The data from the Regional network analysis would have to be made available to the office responsible for the analysis. The procedures for this analysis and the use of the results have not been finalized yet.

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